INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2006/08–3–309–312
http://www. fspublishers.org

Progress of Sorghum Leaf Anthracnose Symptom Types Under Field Fungicide Treatments in the Nigerian Savanna

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ABSTRACT

Field studies were conducted in 1998 and 1999 at the University of Maiduguri Research field in Nigeria to monitor the suppression of the different symptom types of sorghum anthracnose following fungicide treatments. To do this, development of the symptom types: chlorotic flakes on leaves, necrotic flakes on leaf lamina, leaf sheath lesion, leaf lesion, midrib infection, which appeared in sequence were monitored from 45 days after sowing (DAS) the seeds to the crop maturity stage at 85 DAS on the Warwarabashi susceptible cultivar. Our results show that application of either of the seed dressing fungicides metalaxyl and thiram followed by the spraying of either of the systemic foliar fungicides benomyl, Dithane M- 45 and carbendazim three times in the season reduced both the incidence and severity of these symptoms. Treating carbendazim was found to be more effective than the other three treatments in reducing the progress of the disease symptoms. The incidence of leaf anthracnose in general increased even with the applications of the seed dressing fungicides suggesting the importance of the foliar sprays to control the secondary infection coming through the conidia produced from primary infection or from adjacent fields. Primary infection through seed and soil and secondary infection through rain splash of conidia are important sources of inocula of this fungus and must be timely controlled. The sequential application of fungicides in the treatments described is here recommended for sorghum protection where anthracnose is a problem.

Key Words: Anthracnose; *Colletotrichum sublineolum;* Disease progress curves; Fungicides

INTRODUCTION

The fungus *Colletotrichum sublineolum* Henn in Kabát and Bubak is the pathogen causing the anthracnose of sorghum. Anthracnose is an important disease of sorghum in wherever the crop is grown (CABI, 1988). The damage caused by this disease ranges from deterioration of grain to peduncle breakage, stalk rot and foliage damages (Pastor-Corrales & Frederickson, 1980; Gwary *et al*., 2002) and may occur at different stages of plant growth (Warren & Nicholson, 1975; Gwary *et al*., 2003) leading to crop losses depending on the severity of infection and the crop cultivar. Marley, 1996 reported crop losses as high as 47% for Nigeria and similar losses for other West African countries have also been reported by Pande *et al*. (1993) and Thomas *et al*. (1996). Various symptom types of anthracnose appear on sorghum genotypes depending on their level of resistance. Infection of the susceptible cultivar warwarabashi from Nigeria has been shown to include the appearance of chlorotic flakes on the leaf blades, necrotic spots on the leaf lamina, leaf sheath lesion and midrib infection (Gwary *et al*., 2003). If these symptoms are not controlled, both grain and forage yield will be substantially reduced.

The present investigation is a continuation of our previous studies (Gwary *et al*., 2002; 2003), which aims at studying the development of sorghum anthracnose symptoms and their control in the Savanna of Nigeria.

MATERIALS AND METHODS

Field trials were conducted at the Research farm of the Department of Crop Protection, University of Maiduguri, (Latitude 11^{o} 15' N & Longitude 13^{o} 15' E) during the rainy seasons of 1998 and 1999. The experiment consisted of 7 treatments: Apron plus + benomyl (AB), Apron plus + Dithane M- 45 (AD), Apron plus + carbendazim (AC), thiram + benomyl (TB), thiram + Dithane M- 45 (TD), thiram + carbendazim (TC) and a control (Table I). The seeds were treated with the seed dressing fungicides at the manufacturer's rate of 10 g per 3 kg of sorghum seeds, while the foliar fungicides were applied at the rate of 17 kg a.i. ha^{-1} at 45, 60 and 75 days after sowing (DAS). The trials were laid out in randomized complete block design and replicated four times. Inter- and intra-row spacing was at 0.9 m and 0.4 m with four rows per treatment. Data were taken on the two middle rows. The trial was planted when rainfall was fully established; in 1998 planting was done on 15th July, while in 1999 it was planted on the 12th of July. Compound fertilizer (NPK 15: 15: 15) was applied at the rate of 259 kg ha^{-1}, this was followed by side dressing with urea at 4 weeks after sowing at the rate of 100 kg ha^{-1} as recommended for the area (BOSADP, 1989). Manual weeding was done at two weeks after emergence and plants were thinned to two plants per stand. Subsequent weeding was carried out at 4 weeks intervals. All the farm operations and cost of inputs were computed.

Table I. Efficacy of fungicide treatments on leaf anthracnose and grain yield for 1998 and 1999 combined.

Treatment	% Reduction of Disease incidence	% Reduction of Disease severity	Grain yield (tons ha^{-1})	Yield advantage over control (tons ha^{-1})
AB	14.29	75.85	2.76	1.59
AD	17.80	69.23	2.41	1.24
AC	21.08	77.33	2.63	1.46
TB	16.74	70.25	2.11	0.94
TC	13.11	72.48	2.00	0.83
TD	13.35	62.28	1.64	0.44
CONTROL	0.00	0.00	1.17	0.00

DI = Disease incidence; DS = disease severity; control was used as the basis for calculating the % reductions; A = Apron plus; T = Thiram; B = Benomyl; D = Dithane M-45; C = Carbendazim

Inoculation. The trial was established in an anthracnose 'sick plot'. The natural inocula had built up over several years of cultivation of susceptible sorghum cultivars. In addition, the disease pressure was increased by incorporating infected crop residues from every previous growing season, in to the soil during land preparation.

Disease monitoring and assessment. The appearance of disease symptoms following the establishment of the trial was monitored to determine when assessment should begin. At 30 DAS symptoms started to appear but only become visible for assessment at 45 DAS. Disease incidence was then taken as the percentage of total plants showing one or more types of anthracnose symptoms and this was taken at plant maturity stage of 85 DAS. Disease incidence is assessed as the percentage of infected plants per plot.

Disease severity was assessed on 10–tagged plants on a rating scale of 1 - 9 (Sharma, 1983), where: 1 = No symptoms or presence of chlorotic flasks; 2 = 1 - 5% leaf area covered with lesion; 3 = 6 - 10% leaf area covered with lesion; 4 = 11 - 20% leaf area covered with lesion; 5 = 21 - 30% leaf area covered with lesion; 6 = 31 - 40% leaf area covered with lesion; 7 = 31 - 50% leaf area covered with lesion; 8 = 51 - 75% leaf area covered with lesion; 9 = more than 75% area covered with lesion. The values obtained were expressed in % severity.

Grain yield. The grain yield of sorghum tons ha^{-1} was computed from grain yield of each net plot as:

$$\text{Grain yield (tons ha}^{-1}\text{)} = \frac{\text{Grain yield plot}^{-1}\text{ (tons) x 10,000 m}^2}{\text{Net plot size (8 m}^2\text{)}}$$

Data analysis. Data collected were appropriately analyzed statistically. Mean comparisons were carried out using Duncan's multiple range test (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

Symptom appearance and development. The symptoms started to appear at about 35 DAS but were properly visible for assessment at 45 DAS. They appeared first as chlorotic flecks, and then followed by necrotic spots on leaf lamina lesions on leaf sheath and the appearance of the midrib lesions. Symptoms developed and the leaves of un-treated plants became severely infected producing abundant acervuli. The occurrence of these symptom types of epidemiological significance. We have earlier shown (Gwary *et al.*, 2003) that Chlorotic flecks are associated with resistance reaction to anthracnose in sorghum, while high midrib and leaf sheath infections are associated with susceptibility. The ability of the fungicide treatments to control these later two symptoms is important in reducing the risk of crop losses.

Disease progress curves. Fig. 1 shows the incidence of infection of plants in the field with *C. sublineolum* following application of fungicide treatments. During the two years leaf anthracnose incidence increased steadily in un-treated plants reaching about 97% in 1998 and 80% in 1999. The fungicide treatments reduced the initial infection as observed in both years but in 1998 both treated and un-treated plants eventually reached the same level of disease incidence. This suggests that seed dressing alone cannot provide protection for the plants against this disease throughout the growth period. Secondary infection from disease escapes and volunteer crops become important to deal with after the first four weeks of the plants.

Fig. 2 shows the progress of chlorotic flecks on both treated and un-treated plants. In both seasons the chlorotic flecks increased almost linearly from 20% at 45 DAS to a severity of about 55% at 85 DAS irrespective of treatment. Upon application of the fungicides, the symptoms develop gradually at lower levels reaching their peak at 65 DAS and it dropped there-after in the same fashion. Apron plus followed by carbendazim (AC) and Apron plus followed by benomyl (AB) gave better control of this symptom in 1998 but no apparent differences between the treatments in 1999.

The severity of necrotic spots developed fairly linearly from about 20% at 45 DAS to about 55% at 85 DAS. Under the treatments, however, the severity starts to drop at 65 DAS following the second application of the foliar fungicides. In 1999 the fungicides had more impacts on the necrotic spots development than in 1998 when the symptom was kept below the 20% severity. In each of the two seasons both AB and AC were more effective than the rest of the treatments.

The midrib severity was initially low at about 5 - 8% (45 DAS) during both seasons and all treatments. While the midrib was fairly controlled with the fungicides the symptom continued to progress linearly over time in un-protected plants (Fig. 4). The leaf sheath infection followed the same pattern with the midrib infection. Treatments AB and AC further show their effectiveness in Fig. 5.

Fig. 1. Disease progress curve of leaf anthracnose for 1998 and 1999 seasons

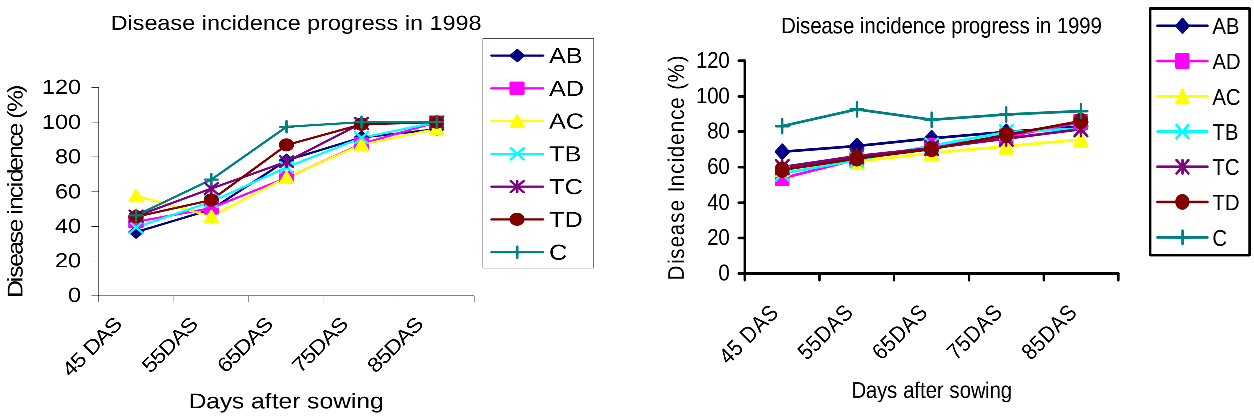


Fig. 2. Disease progress curve of chlorotic flake symptom for 1998 and 1999 seasons

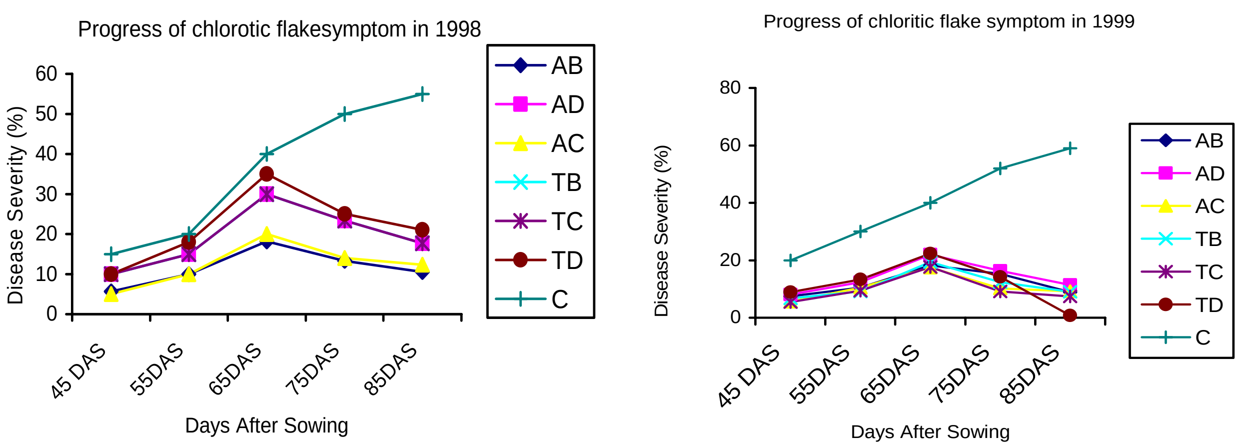
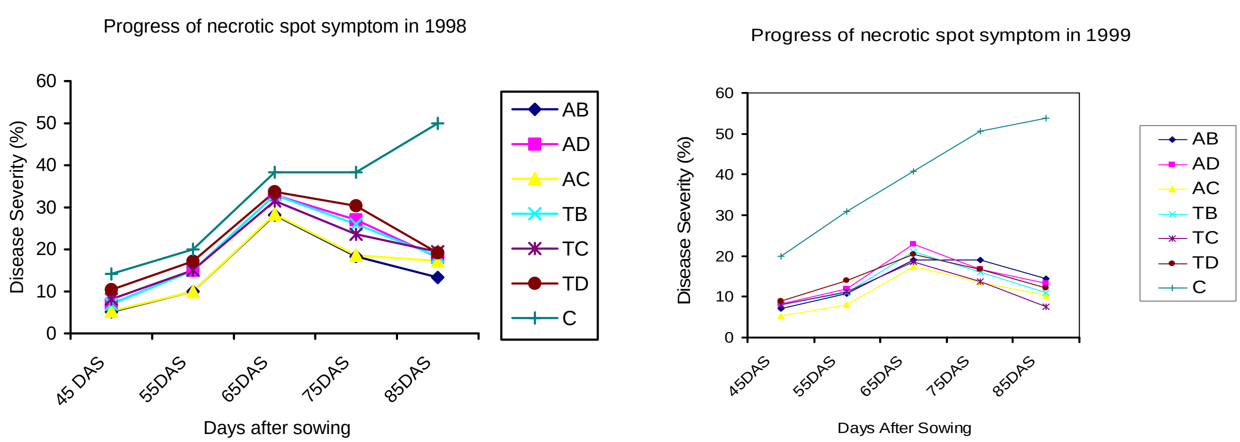


Fig. 3. Disease progress curve of necrotic spot symptom for 1998 and 1999 seasons



Our results show that the acceptability of any control method depends on how much of the disease is controlled by the approach. Table I show the efficacy of the fungicide treatments on the overall anthracnose disease and the yield advantage over control. Our results here shows that three treatments: Apron plus followed by carbendazim or benomyl and thiram followed by carbendazim have consistently showed their efficacy against the fungus *C. sublineolum*. Disease was reduced by 77.33, 75.85 and 72.48%, respectively giving corresponding yield advantages of 1.46, 1.59 and 0.83 tons per hectare. In *in vitro* studies with these fungicides tested against this pathogen

Fig. 4. Disease progress curve of midrib symptom for 1998 and 1999 seasons

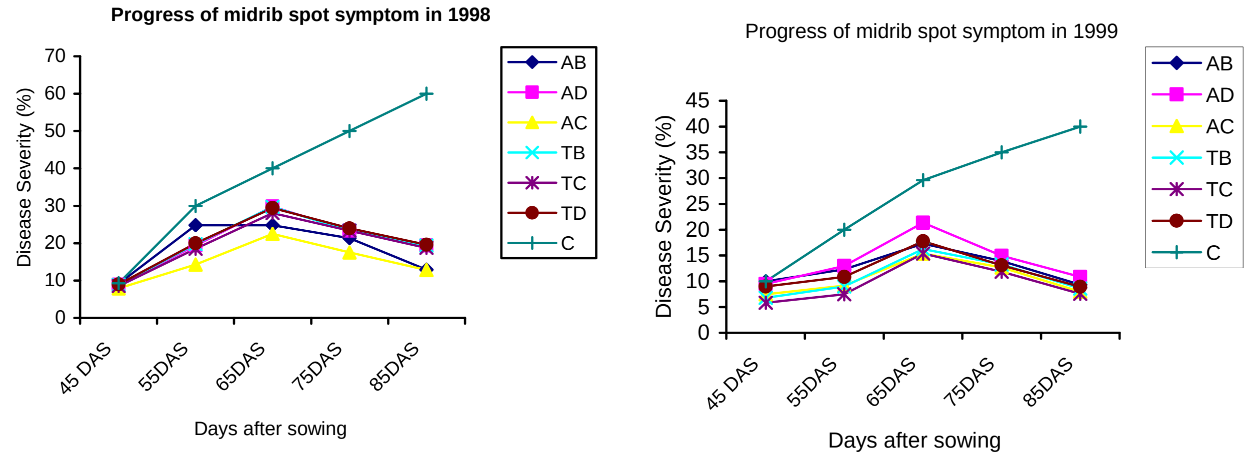
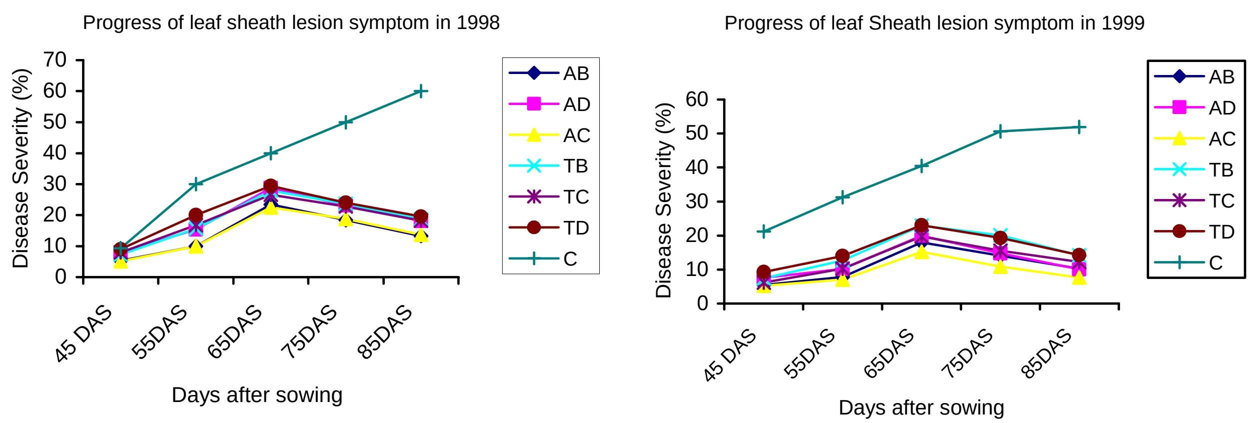


Fig. 5. Disease progress curve of leaf sheath lesion symptom for 1998 and 1999 seasons



individually we have earlier shown [Gwary & Asala, 2006 (in press)] a complete control with Apron plus, thiram and benomyl.

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(Received 03 January 2006; Accepted 10 April 2006)